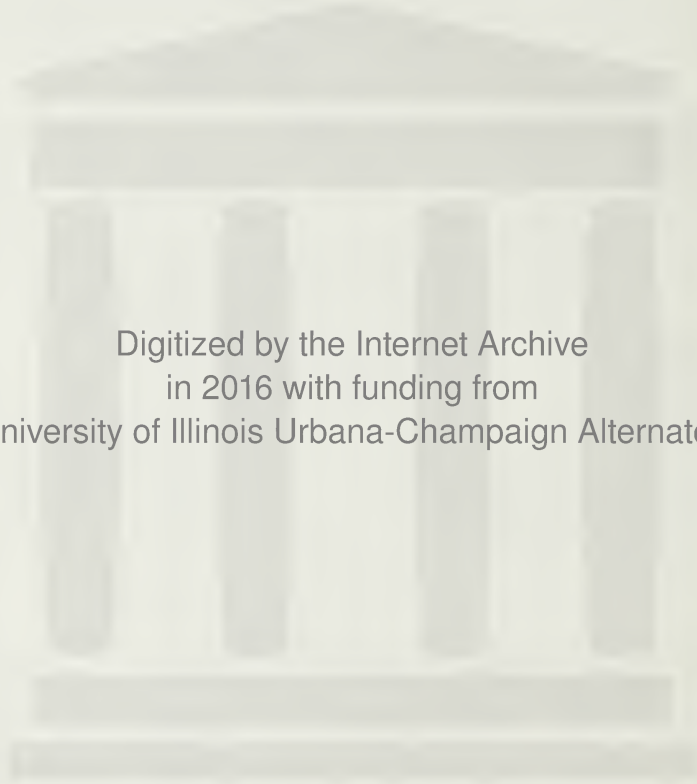


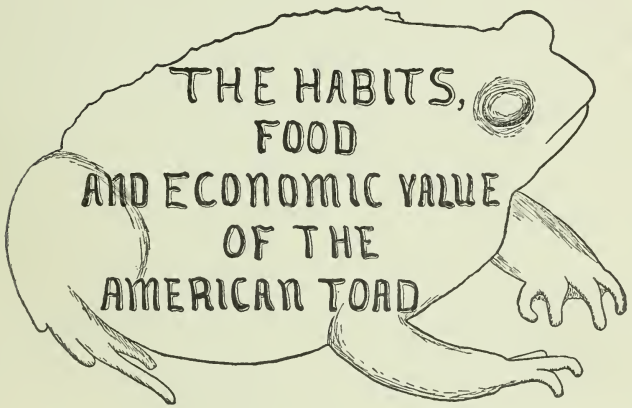
HATCH EXPERIMENT STATION

—OF THE—

MASSACHUSETTS

AGRICULTURAL COLLEGE.

BULLETIN NO. 46.



APRIL, 1897.

The Bulletins of this Station will be sent free to all newspapers in the State and to such individuals interested in farming as may request the same.

AMHERST, MASS.:
PRESS OF CARPENTER & MOREHOUSE,
1897.

HATCH EXPERIMENT STATION

OF THE

Massachusetts Agricultural College,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural, has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are :—

Henry H. Goodell, LL. D.,	*Director.*
William P. Brooks, B. Sc.,	*Agriculturist.*
George E. Stone, Ph. D.,	*Botanist.*
Charles A. Goessmann, Ph. D., LL. D.,	*Chemist* (Fertilizers).
Joseph B. Lindsey, Ph. D.,	*Chemist* (Foods and Feeding).
Charles H. Fernald, Ph. D.,	*Entomologist.*
Samuel T. Maynard, B. Sc.,	*Horticulturist.*
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Henry M. Thomson, B. Sc.,	*Assistant Agriculturist.*
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Robert H. Smith, B. Sc.,	*Assistant Chemist* (Fertilizers).
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Fred W. Mossman, B. Sc.,	*Ass't Chemist*(Foods and Feeding).
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Joseph H. Putnam, B. Sc.,	*Assistant Horticulturist.*
Stephen W. Fletcher, B. Sc.,	*Assistant Horticulturist.*
Benjamin K. Jones, B. Sc.,	*Assistant in Foods and Feeding.*
James L. Bartlett,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists, and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the

Hatch Experiment Station, Amherst, Mass.

Division of Entomology.

The following paper on the habits and food of the American toad has been prepared by my assistant, Mr. Kirkland, from observations made while in the employ of the Gypsy Moth Committee. The results obtained form a considerable addition to our knowledge of the habits and food of the toad and are published here by permission of the committee.

C. H. Fernald.

The Habits, Food and Economic Value

OF THE

AMERICAN TOAD,

Bufo lentiginosus americanus (LeC.)

By A. H. Kirkland, M. S.,

Assistant Entomologist to the Gypsy Moth Committee.

The investigations forming the basis of this paper were made by the writer at spare moments during the summer of 1896. They were not undertaken with a view of exhausting the subject, but rather as an attempt to obtain some adequate idea of the value or non-value of the toad as a destroyer of insects. During the summer of 1895, while studying the habits of the natural enemies of the gypsy moth, the writer observed that in brushlands, large numbers of this insect were destroyed by the toad. To gain farther information concerning its feeding habits, the available literature on batrachians was consulted with the result that an abundance of generalities was found with but few detailed statements of fact. By agriculturists the toad is considered a beneficial creature; by some

entomologists, a good collector of beetles. This appears to represent the sum of the knowledge of the feeding habits of the toad. From the general distribution of this animal, its common occurrence near the abodes of man and its known insectivorous habits, it seemed that an investigation of its feeding habits and food could not be otherwise than interesting and profitable. Owing to the pressure of other duties the writer has been unable to devote to this work the amount of time the subject deserves and no claim is made for completeness of results. It is hoped, however, that they may suffice to call attention to the habits and value of the animal to which they pertain and thus possibly induce others to prosecute farther an investigation of this most interesting subject. At this point, the writer would acknowledge his indebtedness to Prof. C. H. Fernald and President H. H. Goodell for assistance in bibliographical research, and to the former for many valuable criticisms and suggestions. Acknowledgements should also be made to Dr. Leonhard Stejneger, Dr. C. Hart Merriam and Prof. F. E. L. Beal for valuable information.

ANCIENT IDEAS CONCERNING THE TOAD.

That the early students of natural history were in a measure cognizant of the habits of the toad, there is ample evidence in the older writings upon animals, but most unfortunately from a scientific standpoint, the ancient savants who did so much to establish the study of nature, too frequently confounded current superstition with actual fact, and hence we find the early literature upon this interesting batrachian teeming with vague and ludicrous fancies as to its venomous qualities, its medicinal virtues or, most commonly, the hidden toad-stone of priceless value. In this connection it may not be amiss to briefly cite some of these ancient fanciful ideas, for, although they pertain in general to the European species which are distinct from the American, it is quite evident that when our worthy ancestors explored the fauna of our "stern and rock bound coast" they had but little difficulty in adapting the whole host of venerable old world traditions to the new world toads, and thus implanted here superstitions, which, strange as it may seem, still have their devout adherents.

In glancing through the older literature on the toad, we find that the three different groups of fancies indicated above are generally contemporaneous and strangely interwoven. The baleful venom,

the medicinal virtues and the valuable jewel, frequently appear in the same writing associated with minor superstitions, which, though equally ludicrous, never appear to have reached the popularity of the ones cited.

That the toad was venomous was not doubted by the ancients. It was disagreeable, ugly in appearance and "the most deformed and hideous of all animals," hence it must be venomous. Pliny writes of "the venomous frogs and todes called Rubetae which live both on land and in the water." Juvenal makes the Roman dames poison thriftless or uncongenial husbands with a broth made from the toad's entrails. Aelian considered its venom so potent that people might be killed by its breath or glance. Erasmus bears witness to this current belief in his absurd story of the toad and the sleeping monk. Lyly referring to the toad-stone says, "The fayrer the stone is in the toade's head the more pestilent the poyson is in hir bowelles." The uses of adversity are by Shakespeare compared to the "ugly and venomous" toad. According to Valisnerii, the German soldiers, who in 1692 captured the castle of Arceti, amused themselves after the manner of the local peasants in catching frogs and preparing them for the table. To the great joy of the peasants the soldiers did not discriminate between frogs and toads and both were cooked. The natives felt that the hand of Providence had interposed in their behalf and that a wholesale poisoning of their hated captors would result. Soon however their joy was changed to anxiety, to astonishment, and then to a superstitious awe of the gastronomic abilities of the Teutons, for no evil effects resulted. Solenander gives us the interesting account of a thrifty housewife who, finding the support of a sickly husband too great a burden, decided to relieve herself of her marital incubus by means of poison. Carefully calcining a toad, she secretly administered the ashes in a cup of warm drink to her trusting companion and then prepared herself for her anticipated bereavement. To her surprise, the expected did not happen and after several trials the worthy woman became discouraged and the husband was allowed to live to a ripe old age. The Gallic antipathy to the toad is proverbial and may have sprung from the belief that the animal was poisonous. That it is not so regarded by all the French market-men is evident from the statement of Bosc that unscrupulous dealers frequently adulterate their stock of frogs' hind legs with the corresponding members of toads.

A considerable part of the early study of chemistry seems to have

been devoted to an investigation of poisons and a search for antidotes. The doctrine of "similia similibus curantur" was apparently firmly believed and from the most venomous animals and poisonous plants, materials for panaceas, charms and talismans were commonly sought, their efficacy varying directly with the faith of the possessor. It is impossible to state who first promulgated the idea that the toad was the possessor of a stone or jewel that would detect poisons, but it is evident that the belief was current at an early date, as is shown by the following quotation from Brand: "Dr. Bell pointed out that in a translation from Pliny entitled 'Wonders of Nature,' 1569, there is this passage: 'There is found in the heades of old and great *toades* a stone, which they call *borax* or *stolon*; it is most commonly found in the head of a *hee toade*, of power to repulse poisons . . . . '" Boetius writing in the latter part of the fifth century, though skeptical as to the nature of the toad-stone, gives many interesting theories concerning it. Lyly states that "the foule toad hath a faire stone in its head" while contemporary writers make reference to the same subject. Perhaps the most interesting treatises on this subject are those of Browne and of Topsell. The first writer after a full discussion of the beliefs pro and con, decides that "we must with circumspection receive those stones which commonly bear this name, much less believe the traditions that in envy to mankind they are cast out or swallowed down by the toad." He shows how many a venerable fossil fish tooth probably had been "palmed off" upon unsuspecting purchasers and concludes that while a bona fide Bufonite might be possible, the probability of the occurrence was very doubtful. Topsell states "that there be many that ware these stones in Ringes, beeing verily perswaded that they keep them from all manner of grypings and paines of the belly" and describes carefully how a toad-stone was said to be obtained, a process, by the way, involving much strategy. The actual fact of the occurrence of the toad-stone is handled in the following very diplomatic manner: "Therefore they beeing in sundry opinions, the hearing whereof might confound the reader, I will refer him for his satisfaction unto a toade which hee may easily every day kill; and if the stone be found there in substance then is the question at an end." Doubtless had the ancients applied this very simple test, much controversy and brain-fag could have been avoided.

The toad had an important place in the pharmacopoeia of the early days. Pliny states that "it yeelds many good things med-

icinable." Other writers bear testimony to the sovereign power of a dried toad in preventing and curing bleeding from the nose. It is stated that English noblemen used dried toads bound upon the knee as a potent remedy for gout. While the medical practitioners thus found the toad to be of service in curing the ills of the flesh, others versed in magic art were supposed to find in it the acme of venom with which to complete their mysterious preparations.

"Toad that under the cold Stone
Days and Nights has, thirty one,
Swelter'd venom sleeping got,
Boil thou, first ith' charmed' Pot."

Of the fables concerning the toad and spider and their alleged antipathy, so common in the early writings, the ridiculous story related by Erasmus will serve as a fair sample. A worthy monk, so runs the story, was once found by his brethren fast asleep with a large toad seated upon his face. Believing the sleeping brother to be in imminent peril, they at once sought means to deliver him, yet none dared touch the toad. A large spider was seen at the window near by; the sleeping monk was carried to the window when the spider descended and speedily dispatched the toad. Browne, after discussing such absurd fictions, frankly states: "But what we have observed herein, we cannot in reason conceal; who having in a glass included a toad with several spiders, we beheld the spiders, without resistance to sit upon his head and pass over all his body; which at last upon advantage he swallowed down, and that in a few hours unto the number of seven."

So much for ancient European beliefs. Since our toads are congeneric with those of Europe and resemble them closely, and since such superstitions were current at the time of the colonization of our country, it is easy to see how these beliefs were readily applied by the early settlers to our native batrachians Such creations of the imagination seem at the present day scarcely more than ludicrous, yet carefully cherished in an occasional New England family we find fancies equally absurd, such as that touching toads will produce warts on the hands; that killing toads will produce bloody milk in cows; that a toad's breath will cause convulsions in children; that a toad in a newly dug well will ensure a good and unfailing supply of water, or in a new-made cellar will bring prosperity to the household, etc., etc.

In this region the toad usually emerges from its hibernating quarters during the month of April. Cold weather retards its movements, but on warm days at this season the toads may be found on their way to the ponds and stagnant pools, where a little later the characteristic shrill cry may be heard throughout the day and evening. Mating is commenced as soon as the water is reached, or even before, and in a few days the long slimy "ropes" of eggs deposited by the female may be found in the pools. The eggs are nearly black in color and rapidly increase in size. In two weeks the young tadpoles are clearly outlined and in three or four weeks the eggs hatch. The vegetable detritus of the pond bottoms and the slime and algae attached to sticks, plants, etc., seem to be the common food of the tadpole. Bosc is of the opinion that entomostraca, infusoria and water insects are also devoured. Warm weather favors the growth of the tadpoles and usually by July 1-15 the young toads are fully developed, leave the water and spread over the fields. At this stage they are exceedingly sensitive to heat and secrete themselves under leaves, rubbish, stones, etc., during the day; but let a vigorous shower descend and the transformation is magical. The walks, roads and gardens at once become peopled with myriads of these thirsty, leaping creatures, and their sudden appearance has led to the popular belief that they "rain down". It is fortunate for them that when young they are unable to endure solar heat, otherwise large numbers would probably be destroyed by the birds which are active during the day; doubtless many are killed by the predaceous birds and mammals which prowl by night.

Authorities differ as to the age at which the toad begins to reproduce, but probably this does not take place before the fourth year. The number of eggs laid by the adult female is remarkable. From an average-sized female, captured during the spawning season, I removed 1,279 ova and as she had already commenced laying, this figure does not represent her total number of eggs.

The longevity of the toad has been a fruitful theme of controversy. Volumes might be filled with the stories of those found imbedded in rocks, masonry or trees, yet nearly all these statements lack that careful detail of attendant circumstances which is so necessary to remove doubt in the mind of the reader. Of interest in this connection are the experiments of Mr. Herrisant who in 1777 placed three toads in sealed boxes of plaster and deposited them in

FIG. 1. The American Toad, *Bufo lentiginosus americanus (LeC.)*

FIG. 2. Toad in Hibernating Position.

the archives of the French Academy of Sciences. Upon opening the boxes at the end of eighteen months, two of the toads were found to be alive. Dr. Edwards in 1817 repeated these experiments and found that when the boxes were submerged in water the death of the toads speedily resulted. Buckland investigated the matter quite thoroughly by preparing cavities in limestone and sandstone and confining in them toads of various sizes. These stone chambers were then buried three feet deep in a garden. At the end of thirteen months all the toads in sandstone were dead and a like fate overtook those in limestone before the end of two years. These experiments show that it is possible for the toad to exist for a limited time without food, but throw a shadow of improbability upon the stories of those found in rocks, trees, etc.

There are authentic European records of a toad that lived to be thirty-six years old and then was accidentally killed; it seems probable that our American species may be equally long lived, but unfortunately this is a point that apparently has never been noted in our zoölogical literature. Nearly every old New England homestead has one or more semi-domesticated toads whose age can only be conjectured. The writer has sought in different parts of the State, among families who have long resided on the places they now occupy, for some accurate information on this subject, and from a mass of statements, given in many cases with strong corroboratory details, there may be taken apparently veracious records of two toads that have occupied dooryards in two different towns for twelve and twenty-three years respectively. The histories of these toads have been given me by people of unquestionable veracity, yet I hesitate to present the records as facts, since from the evidence offered I cannot feel positive that the identity of the toad in either case has remained unchanged.* There can be but little doubt that toads live to a considerably greater age than is supposed and we may hazard the opinion that many of them reach an age of at least ten or fifteen years.

When suddenly disturbed or roughly handled, the toad ejects a colorless fluid from the anus and a milky liquid from the skin. This habit is probably the basis for the belief that the toad is venomous. The secretion of the skin glands is harmless when applied to the

* Since writing the above, Mr. F. H. Mosher, who has frequently assisted me in various experiments on the gypsy moth and whose accuracy as an observer cannot be questioned, informs me that he has positive knowledge of a large toad that has occupied a dooryard for at least eight years.

hands, but it evidently possesses acrid properties, since when toads are bitten by dogs or cats, the latter usually have a copious flow of saliva, show signs of discomfort and in some cases coming under the observation of the writer, have manifested considerable distress. That this fluid is not objectionable to all animals is apparent from the fact that many hawks, owls, etc., include the toad in their bill of fare. Brocchi found that when injected into a blood vessel of a pigeon this fluid caused the death of the bird.

During the summer months we often find toads of much fresher and brighter colors than their fellows; this is due to a molting of the skin, a process that takes place four or five times each year. The toad is reported to swallow the molted skin, but this I never have been able to witness. Previous to, and for a few hours after molting, the toad remains quiet in some dark or sheltered place.

On the approach of cool weather, sometimes as early as the first of September, toads begin to seek winter quarters. These they find in cellars, under buildings, rocks, leaves or rubbish, and in places where the action of frost will not be felt. Cold benumbs them, but does not kill. In March, 1895, the writer found toads under leaves in the Middlesex Fells when the thermometer stood at about 20° Fh. These animals were apparently frozen, but after being held in the hand for some time, began to show signs of life. In his work on Reptiles and Birds, Figuier states that these animals freeze without being killed, while Buffon is authority for the statement that in the vicinity of Hudson Bay, frogs are frozen hard during the winter, but revive in the spring. A distinction should be made between the hibernation of mammals where the bodily functions though depressed are still performed and that of amphibians, reptiles, insects, etc., where these functions are apparently entirely suspended. Toads do not hibernate singly as a rule and it is not an uncommon thing to find in the winter or spring a dozen or more closely packed together under a rock or board or in some other sheltered spot.

FEEDING HABITS.

The toad cannot endure high temperatures and hence it is not commonly seen in the day time. Properly speaking, it is a nocturnal animal, though it sometimes ventures out during the day when tempted by an abundance of food in its immediate vicinity or, more commonly, when the air is full of moisture. It is an animal that suffers from excessive transpiration of moisture from the body, the

skin being thin and readily permitting the passage of water. That water is probably taken in through the skin is apparent from the sudden appearance of toads during showers or when lawns are being sprinkled.

The toad does not take dead or motionless food. Only living and moving insects, centipedes, etc., are devoured. I have repeatedly seen proof of this fact. Cut worms or other larvae disturbed by the hopping of the batrachian are safe so long as they remain curled up; but immediately they commence to travel they are captured. The toad's tongue (Plate II. figs. 1, 2,), its only organ for seizing food, is soft, extensile, attached in front, but free behind, and is covered with a glutinous substance which adheres firmly to the food seized. So rapid is the motion of this weapon that a careful watch is necessary in order to see the animal feed. The writer once confined for study a large toad in a shaded out-of-door box filled with damp earth. To provide suitable and sufficient food for it was quite a task until an entirely satisfactory expedient suggested itself. A hard bread-crust was soaked in molasses and placed in the cage. Bees, wasps, ants, flies and beetles came to this bait and it was most interesting to watch the toad seize the flying insects, often before they had alighted on the bread. Stinging insects, bees, wasps, etc., when swallowed by the toad apparently produced uncomfortable sensations for a short time. Fish-worms when captured by the toad often prove too much to be swallowed at once and when this is the case the fore-limbs are brought into use to force the unfortunate worm into the capacious gullet of its captor.

At night, soon after sundown, or even before on cool evenings, the toad emerges from its shelter and slowly hops about in search of food. Something of a regular beat is covered by these animals whose sense of locality is quite strong. In the country this includes forays along roadsides, into gardens and cultivated fields, and wherever insect food is abundant and grass or other thick herbage does not prevent locomotion. In cities and suburban villages the lawns, walks and particularly the spots beneath electric lamps are favorite hunting grounds. At Amherst, Massachusetts, the writer once counted eight large well-fed toads seated under an arc light and actively engaged in devouring the insects, which, deprived of wings, fell from the lamp above. Dr. Charles Burleigh, a prominent physician of Malden, Massachusetts, and a close observer in the field of natural science, informs me that a colony of some half-dozen toads

has for some time occupied the sheltered space under the piazza of his house and that each summer night at about eight o'clock, they sally forth down the walk, cross the street and take up their stations under an arc lamp that is located about three rods from the house. Here they remain and feed upon the fallen insects until the electric current is turned off, when they return to their accustomed shelter.

During the past two years the writer has made many observations on toads feeding under natural conditions at all hours of the night. From these observations and from stomach examinations it appears that the toad feeds continuously throughout the night, except when food is unusually abundant. In twenty-four hours the amount of food consumed is equal in bulk to about four times the stomach capacity. In other words, the toad's stomach is practically filled and emptied four times in twenty-four hours. This I have verified by studies on toads confined in cages.

THE FOOD OF THE TOAD.

To establish the economic status of an insectivorous animal two methods of procedure are available: First, observation of the feeding habits; second, stomach examination. Field observations are of high importance as affording correlative and supplementary evidence, but stomach examinations, as Professor Beal has so aptly put it, constitute "the court of final appeal." Good eyesight, patience and strategy will enable one to watch the feeding of insectivorous animals, but identification of insects cannot be made at long range and the material devoured, must be available for careful study. A "slaughter of the innocents" can never be approached with feelings other than those of regret, yet there are occasions where the end justifies the means and this would seem to be the case where investigations are being made in the field of nature with a view of contributing to the sum total of human knowledge. In the investigations on the food of the toad, stomachs were obtained from different parts of the state and more particularly from different kinds of localities, *i. e.*, fields, gardens, marshes, plains, hills, woodlands, etc., during every month of the season of the toad's activity. In this manner one hundred and forty-nine stomachs were collected and examined. This number, the writer fully appreciates, is too small to show the exact status of the toad in this region, yet it is sufficient to afford data for some general conclusions. In nearly every case

the stomachs were examined while fresh; a small number were preserved in formalin for a few weeks before examination.

In making the examinations the stomachs were split along the outer curvature and the contents washed into a glass dish. The material thus obtained was separated into groups and the insects or parts of insects and other animals were identified by comparison with named specimens. The relative per cent by bulk of each class of food was then estimated and the data as to character and amount were noted.

NUMBER OF STOMACHS EXAMINED.

April.	May.	June.	July.	August.	September.	Total.
7	30	66	29	10	7	149

CHARACTER OF STOMACH CONTENTS AND PERCENTAGE OF EACH FOOD ELEMENT.

Unidentified material	5	Carabids,	8	
Gravel,	1	Scarabaeids,	6	
Vegetable detritus,	1	Click beetles,	5	
Worms,	1	Weevils,	5	
Snails,	1	Chrysomelids,	1	
Sow bugs,	2	Carrion Beetles,	1	
Myriapods,	10	Miscellaneous beetles,	1	
Spiders,	2	Total Beetles,		27
Grasshoppers and crickets,	3	Cut worms,	16	
Ants,	19	Tent caterpillars,	9	
		Miscellaneous larvae,	3	
	Total	Cut worms, caterpillars, etc.,		28

The contents of the stomachs examined may be readily separated into three groups, animal, mineral and vegetable, but the presence of substances other than of an animal nature is probably more or less accidental.

Vegetable Matter. Of the total contents of one hundred and forty-nine stomachs, vegetable material formed less than one per cent and from its character appears to have been taken by accident and cannot be properly considered as food. Since the toad takes the greater part of its food from the ground by means of its large, fleshy tongue, nothing can be more natural than that a small quantity of vegetable detritus should be swept into the mouth along with the insects on which the animal feeds. The most common vegetable

substance found in the stomachs is grass, both dry and fresh. Bits of rotten wood, broken acorn shells, seeds of the linden (*Tilea americana*) and maple (*Acer saccharinum*) and bits of apple parings have also been detected. All these vegetable substances were usually associated with a large quantity of ants and other terrestrial insects.

Mineral Matter. The mineral matter found in the stomachs forms slightly more than one per cent of the total contents and consists of gravel, sand, and in a few cases, coal ashes. When a large piece of gravel is swallowed it is regurgitated; this I have proven by experiments on toads in confinement. Otherwise the gravel passes through the alimentary canal and may be found in the castings. Since the toad does not masticate its food, but depends on the stomach for the whole process of trituration it is probable that the gravel when present assists in grinding the strongly chitinized bodies of beetles, etc., yet in the majority of the toads examined there was no gravel present in the alimentary canal although many of the stomachs contained finely ground beetles. A proper inference from the above is that gravel is not essential to digestion in the toad and the writer inclines to the opinion that, as in the case of vegetable matter, the presence of gravel in the stomachs is the result of accident rather than of design. May we not have here a hint as to the origin of the gravel eating habit in birds?

Animal Matter. Animal substances constitute ninety-eight per cent of the total food for the season. They may be readily separated into worms, molluscs, crustaceans, myriapods, spiders and insects, the latter group furnishing by far the greatest percentage. It has been found impossible to recognize sufficiently to refer to its proper class, about five per cent of the animal food, hence no farther reference will be made to it.

Vermes. Earth-worms, *Lumbricus* sp?, constitute one per cent of the whole food. They were found in fourteen stomachs, chiefly those of toads killed soon after showers. Doubtless the rains drove the worms to the surface and thus rendered them easy victims for the toads. Earth-worms in place, as Darwin has so ably shown, are highly beneficial; out of place, as any greenhouse owner can testify, they are decidly obnoxious and often injurious.

Mollusca. Molluscs furnish scarcely one per cent of the total stomach contents, yet it was a pleasure to recognize the common "slug" of the hothouse and garden, *Limax* sp?, in several stom-

achs. Toads taken along the shore at Revere, Massachusetts, yielded several *Melampus bidentatus* Say.* while *Helix* sp? occurred in a few stomachs. An interesting point in this connection is the fact that the shells of these animals were more or less dissolved by the digestive fluids. Shells from the lower part of the stomachs were almost entirely dissolved.

Crustacea. Members of the sub-order Isopoda commonly called "sow bugs," *Oniscus* sp., *Porcellio* sp., occurred in nearly all the stomachs, yet formed but two per cent of the total food. The greatest number were found in September when they constituted six per cent of the food for the month. These creatures are a great nuisance in greenhouses where they eat the roots of orchids, violets, pansies, young roses and other plants. In destroying these crustacea the toad renders a distinct service to gardeners.

Myriapoda. Myriapods form a constant article of diet for the toad. Species of the genus *Julus* were present in the majority of the stomachs examined, the largest number found in a single stomach being seventy-seven. These creatures form ten per cent of the food for the season. They are commonly injurious to low growing fruits and garden crops, as a glance through the literature of economic entomology will amply prove. Of the damage to potato crops occasionally resulting from these myriapods, Prof. J. A. Lintner has given a most excellent account in his third report on the Insects of New York, page 133. Prof. C. H. Fernald informs me that a species of *Julus* often attacks newly planted potatoes. In greenhouses they feed upon plants in beds and destroy the roots of lettuce, geraniums, orchids, etc.

Arachnida. Spiders occur in the stomachs of toads in all months, but form only two per cent of the total food. This destruction of spiders should be counted against the toad, since they feed on flies, small moths and other insects, many of which are obnoxious or injurious to man. The damage resulting from the destruction of this small quantity of spiders, however, may be counterbalanced by the benefit from the killing of injurious "sow bugs" and snails.

* Kindly identified for me by Mr. John Ritchie, Jr., Boston, Massachusetts.

FIG. 1. The Squash Bug, *Anasa tristis.*

Insecta. We now come to the most interesting phase of the whole question of the economic value of the toad, a consideration of the insect food. Insects constitute seventy-seven per cent of the total food for the season and the natural orders represented contribute the following percentages : Orthoptera, three per cent ; Hymenoptera, nineteen per cent; Coleoptera, twenty-seven per cent; Lepidoptera, twenty-eight per cent. A few Hemiptera and Diptera were found, but these taken together do not form one per cent of the whole food.

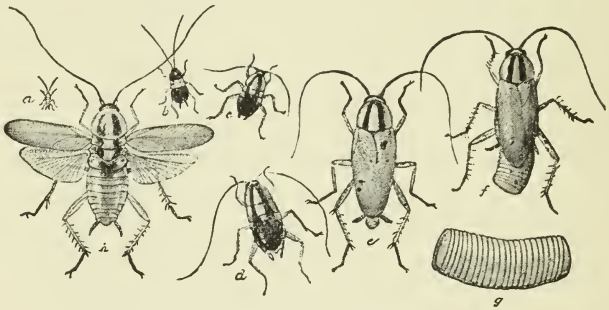


FIG. 2. The German Roach, *Blatta germanica.*

Orthoptera were found in the stomachs throughout the season, reaching their maximum in September when they formed eight per cent of the food for the month. The common cricket, *Gryllus luctuosus* Serv., and the cockroach, *Blatta germanica* Fab., were frequently recognized in the stomach contents. The value of the toad as a destroyer of roaches has been commented on by Mr. W. W. Meech in Insect Life, Vol. 1, page 341, where it is stated that the toad "will clear your room of cockroaches over night just as he will your garden of the vilest of your insect foes." The species identified are more or less injurious and the three per cent of Orthoptera consumed by the toad should be placed to its credit.

FIG. 3. The Wingless Grasshopper, *Ceuthophilus maculatus.*

Aside from ants, two humble bees, one *Augochlora* sp., eight wasps and two ichneumons comprise the representatives of the Hymenoptera recognized in the stomachs examined. Ants are the most constant food-element found in the stomachs and constitute nineteen per cent of the total food for the season. The highest percentage of these insects was recorded in May when ants were found in twenty-one of the thirty stomachs examined, formed thirty-three per cent of their contents and twenty-three per cent of the food for that month. The toad is a well known ant-eater and one occasionally sees it even at midday, emerging from its hiding place to feed upon a passing swarm. Opinions differ as to the economic value of ants. They are such models of industry and show such a high grade of intelligence that some authorities are disposed to regard their short-comings with a lenient eye. Concerning the value of the species of *Camponotus* and *Formica* the writer sought the opinion of Prof. L. O. Howard and received the following reply: "I have talked with Mr. Pergande, who has long studied our ants, as you doubtless know, and I am able to give you the following information: On the whole the character of the common black ants of the genera *Camponotus* and *Formica* is negative. They feed upon dead insects and, to some little extent, on living insects, and on honey dew, whether secreted by plant lice, bark lice, galls, or by the nectar glands of plants themselves. The number of injurious insects killed, on the whole, is very small. They do not transport plant lice and care for them to any extent; that is to say, they are not anything like as injurious in this way as are ants of other genera. They are occasionally somewhat annoying in houses, but do not form their nests in the timber of buildings unless it is rather decayed."

FIG. 4. The Red Ant, *Monomorium pharaonis*.

The chief service rendered by ants is the killing of a few injurious insects. On the other hand they infest lawns and houses and render themselves generally obnoxious around the dwellings of man. During the past summer I have observed somewhat closely the habits of the species most frequently found in the stomachs, *Camponotus pennsylvanicus* DeG. and have seen them destroy but few living insects while they did destroy a large number of moths on spreading boards and committed many other depredations around our Malden laboratory. In the vicinity of Boston where many buildings are sup-

ported by piles more or less decayed, this species is a common and very annoying household pest. I have discussed the economic value of these ants with Professor Fernald and he agrees with me in the conclusion that so far as the toad destroys these insects it should be considered a beneficial animal.

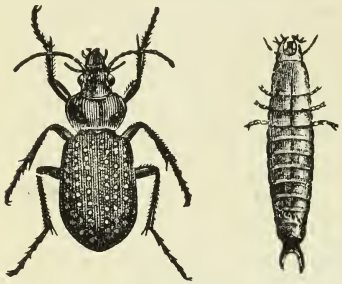


FIG. 5. A "Cut Worm Killer", *Calosoma calidum*.

Coleoptera form twenty-seven per cent of the total food and are chiefly represented by Carabids, Scarabaeids, Elaterids and weevils. Carabidae were found to be a constant article of food throughout the season and form eight per cent of the total food. *Calosoma calidum* Fab. was found in six stomachs and in one case a specimen of this insect was taken alive from the stomach of a toad captured late at night. The insect lived for about twelve hours afterward. The per cent of Carabidae consumed is nearly constant throughout the season, the maximum being nine per cent for the month of June. The destruction of insects of such well known predaceous habits counts strongly against the toad. The larger Carabidae are especial enemies of terrestrial lepidopterous larvae and render much valuable service by destroying cutworms.

FIG. 6. *Harpalus caliginosus.*

FIG. 7. The Rose Chafer, *Macrodactylus subspinosus.*

Against the killing of these beneficial insects may be reckoned the consumption of a large number of Scarabaeids, Elaterids and weevils. The Scarabaeidae, of which family the May-beetle and Rose-chafer are typical representatives, form six per cent of the whole food. These insects in their larval stage feed largely upon the roots of grass and, as in the case of the May beetle, frequently cause great damage to grass lands and pastures. In the mature form some of them, like the Rose chafer, devour the blossoms and leaves of ornamental plants and cultivated crops.

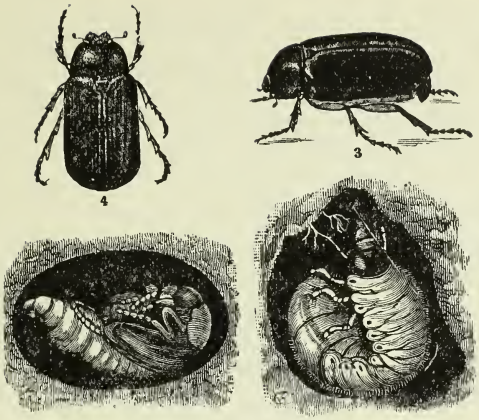


FIG. 8. The May Beetle, *Lachnosterna fusca*.

The frequent damage to the potato crop resulting from the ravages of the white grub is a matter of common knowledge. *Lachnosterna fusca* Fröh. was found in eighteen stomachs, one of which contained four of these beetles. *Macrodactylus subspinosus* Fab. and *Euphoria inda* Linn. were of frequent occurrence in the stomachs. Elateridae form five per cent of the total food. These "click beetles" being the parents of wire-worms should be reckoned as injurious species. Nearly every farmer in Massachusetts has suffered to a greater or less extent from having his sprouting grain or potatoes partially destroyed by wire worms. Cabbages, lettuce, and potato vines are frequently damaged by them. Five per cent of the total food was found to be composed of weevils, insects of generally injurious character. The plum curculio was found in two stomachs while some of the other species recognized are of importance as being borers in standing timber and shade trees.

FIG. 9. The Indian Cetonia, *Euphoria inda*.

FIG. 10. A Click beetle.

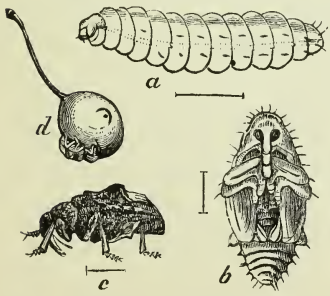


FIG. 11. The Plum Curculio, *Conotrachelus nenuphar*.

FIG. 12. *Pandeletejus hilaris*.

FIG. 13. *Hylobius pales*.

Chrysomelids, carrion beetles and miscellaneous beetles form one per cent each of the total stomach contents. The Chrysomelidae as a whole are leaf-eaters and include such injurious species as the potato beetle and striped cucumber beetle, both of which were identified in the stomachs. The carrion beetles, while of no great economic importance are sometimes indirectly helpful to man since they contribute somewhat to his comfort by seeking out and burying carrion that might otherwise be offensive. For this reason they may be considered as beneficial insects and their destruction as counting slightly against the toad. The miscellaneous beetles include scattering representatives of many families and, aside from a few Coccinellids, are of no particular importance from an economic standpoint.

FIG. 14. *Chrysomela scalaris.*

FIG. 15. *Megilla maculata.*

FIG. 16. *Coccinella sanguinea.*

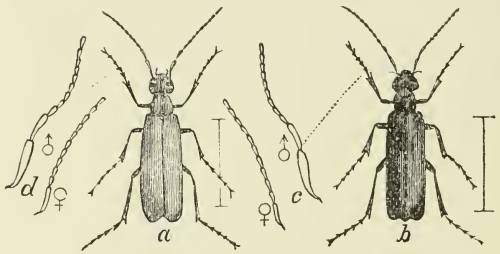


FIG. 17. FIG. 18.

Blister beetles.

Of the Lepidoptera, but few mature insects were found in the stomachs examined. One crambid and four noctuid moths represent the total imagoes. Lepidopterous larvae, however, form the chief food (twenty-eight per cent), for the whole season. They may be divided into three groups: cut worms, sixteen per cent; tent caterpillars, nine per cent; and miscellaneous larvae, three per cent. Among the latter such injurious species as *Euvanessa antiopa*, *Porthetria dispar*, *Pyrophila pyramidoides* and *Paleacrita vernata* were often present. It would seem as if the armor of the Vanessa larva

would serve as a protection against the toad, but the stomach that is able to receive and peacefully digest "yellow jacket" wasps does not flinch before the spiny covering of this caterpillar. Six full grown larvae of this species were taken from a single stomach.

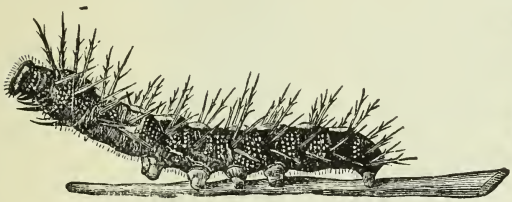


FIG. 19. Larva of *Eurauessa antiopa.*

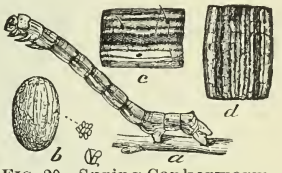


FIG. 20. Spring Cankerworm, *Paleacrita vernata.*

In eastern Massachusetts where brushland is infested by the gypsy moth, the toad renders considerable service in destroying the caterpillars of this highly injurious insect. The stomachs of three toads captured in such an infested spot contained respectively seven, fifteen and sixty-five gypsy moth larvae.* Contrary to the usual habits of the animal, these toads were feeding at midday and on a high, dry hillside, doubtless being attracted from their accustomed haunts by the abundance of caterpillars.

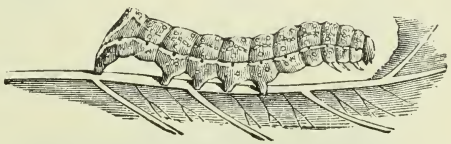


FIG. 21. Larva of *Pyrophila pyramidoides.*

Tent caterpillars were found only in stomachs taken in May and June. In the former month they formed eighteen per cent of the food. At the time when these insects are fully grown and are crawling over the ground in search of a suitable place for pupation, they fall an easy prey to the toad. The remains of thirty-seven full grown tent caterpillars were taken from a single stomach while many others contained from fifteen to twenty. Since this insect is an apple tree pest of the first rank, the good work of the toad in this connection is entitled to high commendation.

*The Gypsy Moth, Forbush-Fernald, 1896 p. 404.

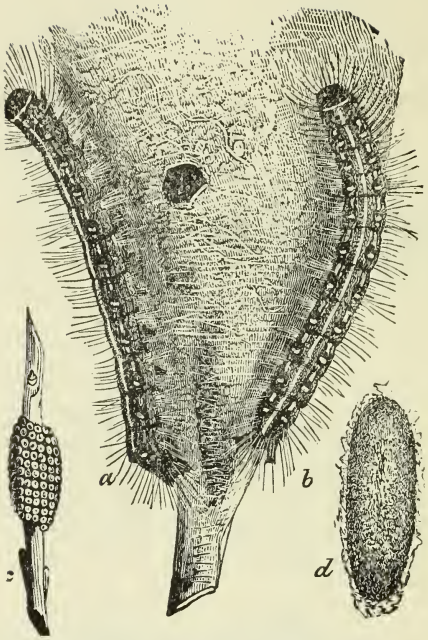


FIG. 22. Tent caterpillar, *Clisiocampa americana*.

FIG. 23. Forest Tent Caterpillar, *Clisiocampa disstria*.

The damage caused by cut worms to lettuce, cabbage, cucumbers, peas, beans and in fact to nearly all young garden crops is a matter only too well understood by farmers and it is a pleasure to record that sixteen per cent of the total food of the toad is composed of these nocturnal destroyers of vegetation. These insects remain in concealment during the day and feed by night, hence it is to nocturnal animals like the toad that the farmer must look for a natural check upon their ravages.

FIG. 24. The Army worm, *Leucania unipuncta.*

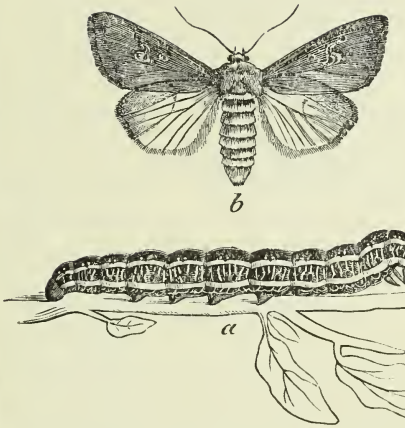


FIG. 25. A Cabbage pest, *Mamestra picta.*

During the army worm outbreak of the past year, the writer had occasion to observe the toad in the role of a destroyer of this insect. At Hingham, Massachusetts, two toads were observed busily engaged in feeding upon a migrating "army" of these larvae while in all the devastated fields toads were very abundant. Dissections of three toads taken in infested fields revealed the presence of nine, eleven and fifty-five army worms in their respective stomachs.* When one considers the annoyance and damage caused by cut worms, the value of the toad is at once apparent. These insects are

*Mass. Crop Report, July 1896, p. 35.

of such habits that their destruction is a matter attended with considerable difficulty and it is as a destroyer of cut worms that the toad renders the most important service to the agriculturist.

The evidence in regard to the economic value of the toad may be thus summarized :—

1. It destroys carabid beetles, insects of a highly beneficial character.

2. It devours an occasional ichneumon fly and "lady bird", beneficial insects.

3. It feeds to a small extent on spiders, generally considered to be valuable as insect destroyers.

4. It devours carrion beetles, insects indirectly helpful to man.

1. It feeds on worms, snails and sow bugs, common greenhouse pests.

2. It devours a large number of myriapods which damage greenhouse and garden plants.

3. It feeds to some extent on grasshoppers and crickets.

4. It destroys large quantities of ants, insects often injurious and usually obnoxious.

5. It consumes a considerable quantity of May beetles, Rose chafers, "click beetles", potato beetles, cucumber beetles and weevils, all more or less injurious to crops of various kinds.

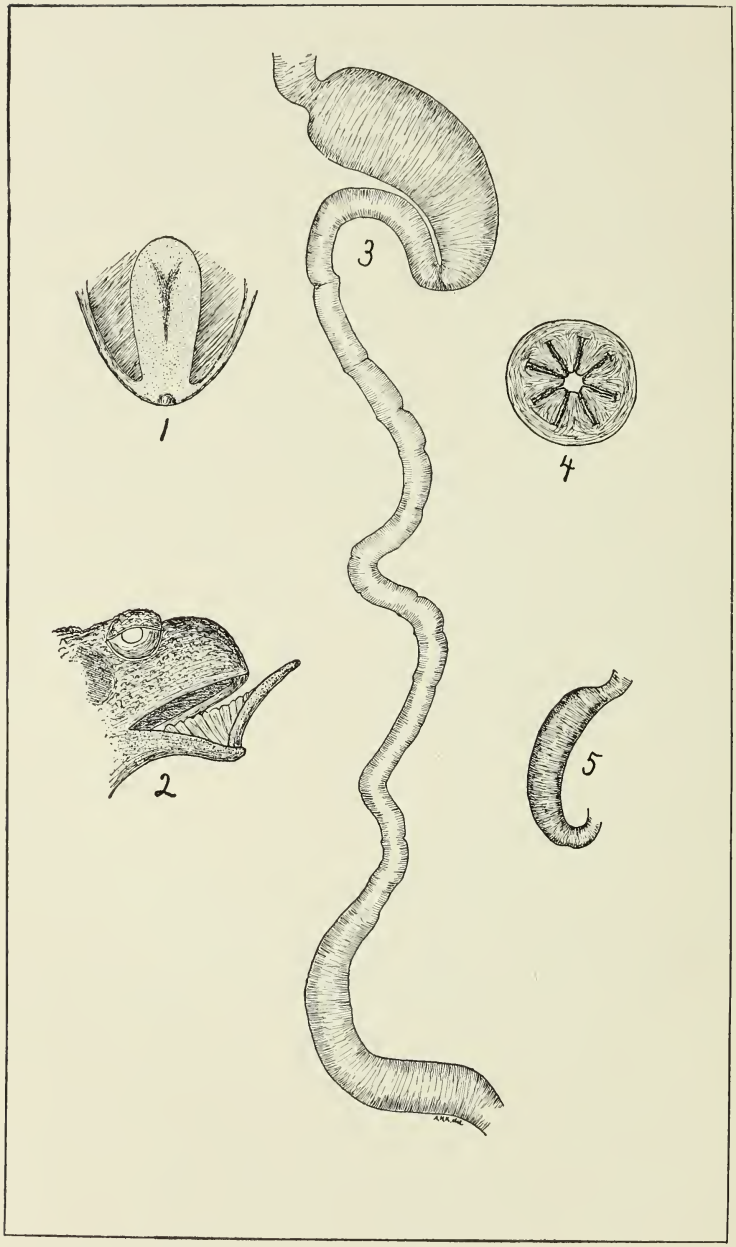
6. It feeds on tent caterpillars, gypsy moths and other fruit tree pests.

7. It is a prime destroyer of cut worms and army worms, common pests which often cause great damage.

To recapitulate, eleven per cent of the toad's food is composed of insects and spiders beneficial or indirectly helpful to man ; eighty-per cent, of insects and other animals directly injurious to cultivated crops or in other ways obnoxious to man. Farther comment upon the valuable services of the toad would seem unnecessary.

LIST OF INSECTS FOUND IN THE STOMACHS EXAMINED.

The following list includes a part of the species found in the stomachs. In many cases, particularly with lepidopterous larvae, specific or even generic identifications could only be made of a limited proportion of the whole number of insects present. Since the toad swallows its food intact, a large part of the hard-bodied insects could be identified.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HYMENOPTERA.

Bombus vagans Smith.
Augochlora sp?
Vespa diabolica Sauss.
Vespa vulgaris Linn.
Camponotus pennsylvanicus DeG.
Formica rufa Linn.
Formica subsericea Say.
Monomorium pharaonis Linn.
Ichneumon funestus Cress.
Ichneumon sp.

COLEOPTERA.

Cicindela 6-guttata Fab.
**Calosoma calidum* Fab.
Pterostichus sp?
Amara sp?
Platynus sp?
Dromius sp?
Pinacodera sp?
Harpalus sp?
Anisodactylus sp?
Necrophorus tomentosus Web.
Silpha americana Linn.
Staphylinus maculosus Grav.
" *cinnamopterus* Grav.
Ocypus ater Grav.
Megilla maculata DeG.
Coccinella trifasciata Linn.
" *sanguinea* Linn.
Adalia bipunctata Linn.
Hister foedatus Lec.
Melanotus fissilis Say.
" *communis* Gyll.
" *sagittarius* Lec.
Asaphes memnonius Hbst.
Dicerca divaricata Say.
Geotrupes splendidus Fab.
Serica vespertina Gyll.
Macrodactylus subspinosus Fab.
Lachnosterna fusca Fröh.
Aphonus tridentatus Say.
Euphoria inda Linn.
Phymatodes variabilis Fab.
Doryphora 10-lineata Say.
Chrysomela similis Rog.
" *spiraeae* Say.
Diabrotica vittata Fab.
Tenebrio molitor Linn.
" *larva* sp?
Helops micans Fab.
Epicauta cinerea Forst.
Otiorhynchus sulcatus Fab.
" *ovatus* Linn.
Pandeletejus hilaris Hbst.
Ithycerus noveboracensis Forst.
Hylobius pales Hbst.
Conotrachelus nenuphar Hbst.
Cryptorhynchus lapathi Linn.

LEPIDOPTERA (larvae).

Euvanessa antiopa Linn.
Clisiocampa americana Harr.
" *disstria* Hbn.
Arsilonche albovenosa Goetze.
Rhynchagrotis alternata Grt.
Agrotis sp?
Noctua c-nigrum Linn.
Noctua clandestina Harr.
Carneades sp?
Mamestra picta Harr.
Nephelodes minians Gn.
Leucania unipuncta Haw.
Pyrophila pyramidoides Gn.
Paleacrita vernata Pack.

*For the identification of the Carabidae I am indebted to the courtesy of Mr. A. F. Burgess.

HEMIPTERA.

Euschistus fissilis Uhl. *Ceresa* sp?
Anasa tristis DeG.

ORTHOPTERA.

Gryllus luctuosus Serv. *Pezotettix* sp?
Ceuthophilus maculatus Harr. *Melanoplus femoratus* Burm.
Xiphidium brevipenne Scud. " *femur-rubrum* DeG.
Blatta germanica Fab.

DIGESTION: AMOUNT OF FOOD.

The digestive process in the toad is one of trituration and solution. The muscular stomach grinds the food while the acid digestive fluids soften and render assimilable the various food elements. Samples of the digestive fluids of the toad submitted for analysis to Mr. F. J. Smith, Chemist to the Gypsy Moth Committee, were found by him to be rich in hydrochloric acid and to contain a small amount of phosphoric acid. That the digestive process is ordinarily a continuous one is shown by the fact that in a majority of the stomachs examined the food at the pylorus was finely ground and nearly digested, while that near the cardiac orifice was intact and, to all appearances, but recently swallowed.

The quantity of food that can be accommodated in the stomach of the toad is remarkable. As stated on previous pages, the remains of seventy-seven myriapods were found in a single stomach, fifty-five army worms in another, sixty-five gypsy moth caterpillars in a third, and thirty-seven tent caterpillars in a fourth. In these cases, however, but one kind of food was present and the toads were above the usual size. On one occasion Mr. J. E. Wilcox, a former employee of the Gypsy Moth Committee, fed to a toad of medium size twenty-four fourth-molt gypsy moth larvae, all of which were swallowed in less than ten minutes. Mr. F. H. Mosher once fed a toad upon a quantity of full-grown celery worms (*Papilio asterias*) and in three hours' time the animal had consumed between thirty and thirty-five. In this case the toad rested at intervals of about twenty minutes each between the times of feeding.

In looking over my notes on the stomach examinations, I find a record of a toad killed at 9 : 00 P. M., May 11, 1896, whose stomach contents represent a fair average of the whole number of stomachs examined, both for variety and quantity of food elements. In the stomach contents were recognized :—

9 ants (*Camponotus pennsylvanicus*).
6 cutworms.
5 myriapods (*Julus* sp?).
6 sow bugs (*Porcellio* sp?).
1 weevil (*Hylobius pales*).
1 carabid beetle (*Pterostichus* sp?).

As previously stated, in twenty-four hours the toad consumes an amount of food equal to that required to fill the stomach four times. A toad feeding at this rate upon the same kinds of food and in the same proportions as in the case cited would devour in the three months of May, June, and July the following quantities of food: 3,312 ants, 2,208 cut worms, 1,840 myriapods, 2,208 sow bugs, 368 weevils and 368 carabids. Or in other words, in the three months a toad would consume 368 beneficial insects and 9,936 injurious insects, myriapods, etc.

To properly estimate the financial equivalent of the damage and annoyance that might be caused by these insects would be a difficult and unsatisfactory task, since data for the calculation must be of an arbitrary nature. If we confine our attention to but one element of the food, the cutworms, we reach some very interesting results. If we assume that ten per cent of these insects, eaten by a toad feeding under the given conditions, would have been killed by the carabid beetles which the toad also devours, we still have the destruction of 1,988 cutworms to place to the toad's credit. If the damage the cut worms would have caused be estimated at one cent per worm, a figure which gardeners and tobacco growers will probably consider ridiculously low, we find that in one season a toad might destroy cutworms which otherwise would have damaged crops to the extent of $19.88.

HOW THE TOAD MAY BE MADE USEFUL.

To all agriculturists the toad renders conspicuous service, but gardeners and greenhouse owners may make this animal of especial value. Every gardener should aim to keep a colony of toads among his growing crops and the practice of collecting and transferring them to the gardens is a commendable one. While the sense of locality is strong in this batrachian and it will often return over considerable distances to its original haunts, yet it may be induced to remain in new quarters if there is a sufficient food supply. Many

farmers provide toads with artificial shelters made by digging shallow holes in the ground and partially covering them with a bit of board or flat stone. In such places toads will often remain for many days, sallying forth at night to seek food.

In greenhouses the toad may be made of particular value as a destroyer of snails, sow bugs, myriapods, cut worms and weevils. According to Dr. Ritzema Bos, "in the research garden attached to the Rouen entomological laboratory the snails were entirely exterminated in 1891 as a result of introducing one hundred toads and ninety frogs." In a greenhouse at Malden, Massachusetts, a number of valuable orchids were nearly ruined through the attacks of myriapods and sow bugs. The gardener introduced a number of toads and in a few weeks the pests had nearly disappeared and all damage from that source ceased. A common pest in rose-houses and one that is increasing in spread and damage, is Fuller's rose beetle (*Aramigus fulleri*). While this species has never been identified in the stomachs examined, yet from the common occurrence of other weevils in the stomachs there can be no doubt but that toads confined in rose-houses would render material aid in destroying this insect. It would be necessary to jar the beetles from the bushes at intervals when the toads would doubtless devour the greater part of the weevils falling to the ground.

NATURAL ENEMIES.

The crow and various species of hawks and owls are the chief natural enemies of the toad. According to Prof. W. B. Barrows,* "it is certain that crows consume large numbers of toads and frogs." Examinations made by him of the stomachs of a large number of crows show that the toad is a common element in the food of this bird. From Dr. A. K. Fisher's Report on the Hawks and Owls of the United States, I take the following list of birds known to feed on the toad: red-tailed hawk, broad-winged hawk, red-shouldered hawk, screech owl. To the above list my friend, Mr. F. H. Mosher, adds the marsh hawk, which, he states, is one of the worst enemies of toads, destroying large numbers of them during the spawning season. Mr. Mosher also informs me that he has found a toad in the nest of a Cooper's hawk. It is probable that all the hawks and owls occurring in this region feed upon the toad to a considerable extent. While young toads are migrating from the ponds, many of them are destroyed by hens, ducks and guinea fowls. Several snakes have

*The Common Crow, Bull. 6, U. S. Dep. Agr. Div. of Ornith. and Mamm. 1895, p. 51.

been reported to me as destroying toads, but unfortunately none were submitted for identification. In Germany, a dipterous parasite, *Lucilia sylvarum* Meig., has been reared from the European toad and larvae, apparently those of *Lucilia*, were found by Meinert in the eye of a toad.

As a common enemy of the toad the ubiquitous small boy plays a prominent part. At Malden, Massachusetts, the writer once found seventeen toads dead and more or less mutilated, lying on the shores of a small pool. This was the result of a couple of hours' *amusement* on the part of two juveniles. This is not an extreme case.* Such cruel and senseless persecution is only of too common occurrence. The loud cry of the toad at spawning time readily betrays its presence, and small boys, and sometimes those of a larger growth gravitate toward the pools as naturally as do the toads themselves. There have been excellent laws enacted to protect our insectivorous birds. Why should there not be as stringent legislation against the destruction of toads? If merit of service rendered to man be the standard by which legislation is determined, the toad presents a record which will compare favorably with that of any insectivorous bird. Public sentiment in a matter like this, however, exerts a stronger influence than legislation, and when the services of this animal are appreciated and the toad receives in our public schools recognition similar to that given to the birds, then we may expect to see a lessening of the wanton destruction of this humble servant of man.

*Since the above was written, Dr. C. F. Hodge has published in the *Worcester Evening Gazette*, Mar. 31, 1897, an account of finding in a single day 200 dead and wounded toads on the shores of a small pond on the grounds of Clark University.

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EXPLANATION OF PLATE II.

Figure 1. Lower jaw of toad showing attachment of tongue.
" 2. Side view of head showing tongue in action.
" 3. Alimentary canal stripped of appendages.
" 4. Cardiac orifice of stomach enlarged.
" 5. Empty stomach.

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